METHOD AND APPARATUS FOR USE OF A SELF-TAPPING RESORBABLE SCREW

FIELD OF THE INVENTION

[0001] The present invention is generally related to a bone attachment device and, more particularly, to a method and apparatus for implanting a self-tapping resorbable bone screw with locking and soft tissue graft securing features.

BACKGROUND OF THE INVENTION

[0002] Modern medical techniques include suturing soft tissue to bone and repair of bone during, for example, reconstructive surgery. In one form these techniques involve attaching a suture to a bone screw, or anchor, installing the bone screw into the bone and connecting the soft tissue to the bone via the suture. One drawback associated with prior art bone screws is the potential for a bone screw to back out after implantation. To inhibit back out, bone screws have been modified with various thread designs and locking features, with some success.

[0003] These bone screws can also be used for repair of bone by inserting the screw into a prepared bone aperture. The screw can be used to attach bone to bone or to attach a reconstruction plate or other prosthesis to a bone. Most of these techniques can benefit from the use of a resorbable screw with a self-locking feature. When installing a bone anchor or screw, a surgeon will typically tap a hole, remove the tap and then install the screw into the hole

while maintaining the alignment of the bone with another bone or a prosthesis. Therefore, what is needed is an implantation system for a bone screw utilizing a self-tapping resorbable screw with a soft tissue attachment and locking features for repair of bone or soft tissue graft attachment.

SUMMARY OF THE INVENTION

[0004] In accordance with the teachings of the present invention, a method and apparatus for a self-tapping resorbable bone screw system and locking feature to secure a soft tissue graft is disclosed. In one form, the present invention provides a channeled screw having a generally cylindrical body, a threaded outer surface and a channel defining an interior locking surface and a tap that is configured to fit within the channel such that the channel screw can be threaded into a bone aperture as the tap forms threads within the bone aperture.

[0005] In another form, the present invention provides a method of installing a bone anchor to a bone wherein a bone screw and tap are threaded into a bone aperture and the tap is removed forming a longitudinal slot within the bone aperture and a staple is inserted into the slot. The staple can then be used to lock the bone screw in place and prevent relative rotation between the bone screw and the bone and also the staple can be used to secure a soft tissue graft.

[0006] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating

the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0008] Figure 1 is a perspective view of a bone screw in accordance with the teachings of the present invention;

[0009] Figure 2 is a sectional side view of the bone screw of Figure 1;

[0010] Figure 3 is a top view of the bone screw of Figure 1;

[0011] Figure 4 is a bifurcated tap in accordance with the teachings of the present invention;

[0012] Figure 5 is a perspective view of the tap of Figure 4 installed within the bone screw of Figure 1, forming a screw implantation system aligned with a bone aperture;

[0013] Figure 6 is a sectional top view of the screw implantation system of Figure 5taken along the line 6-6;

[0014] Figure 7 is a side sectional view of the screw implantation system of Figure 5 illustrating the system inserted within a bone aperture;

[0015] Figure 8 is a perspective view of a staple in accordance with the teachings of the present invention;

[0016] Figure 9 is a perspective view similar to figure 8, but taken from a different angle of view than of Figure 8;

[0017] Figure 10 is an alternate embodiment of a staple in accordance with the teachings of the present invention;

[0018] Figure 11 is a perspective view of a bone screw in accordance with the teachings of the present invention installed within a bone and having a bone staple attached therein wherein a soft tissue graft is interposed therebetween;

[0019] Figure 12 is a top view of the bone screw of Figure 11 with the soft tissue graft removed for clarity;

[0020] Figure 13 is a side view of the bone screw of Figure 12 taken along the line 13-13;

[0021] Figure 14 is a top view of an alternate embodiment of the bone screw of Figure 1, with the anchor locking surface removed for clarity;

[0022] Figure 15 is a side view of the bone screw of Figure 14;

[0023] Figure 16 is a top view of a further alternate embodiment of the bone screw of Figure 1;

[0024] Figure 17 is a side view of the bone screw of Figure 15;

[0025] Figure 18 is a top view of an alternate embodiment of the staple of Figure 8;

[0026] Figure 19 is a side view of the staple of Figure 18;

[0027] Figure 20 side view of an alternate embodiment of the bone screw of Figure 1, configured to attach to the staple of Figure 18;

[0028] Figure 21 a perspective view of a further alternate embodiment of the staple of Figure 8;

[0029] Figure 22 side view of an alternate embodiment of the bone screw of Figure 1, configured to attach to the staple of Figure 21;

[0030] Figure 23 is a perspective view of an alternate embodiment of the staple of Figure 8; and

[0031] Figure 24 is a perspective view of a further alternate embodiment of the staple of Figure 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] The following description of the embodiments of a method and apparatus for implantation of a bone screw are merely exemplary in nature and are in no way intended to limit the invention, its application, or uses. Moreover, while the present invention is described in detail with reference to a resorbable polymer bone screw, it will be appreciated by those skilled in the art that the present invention is not limited to a resorbable polymer but the bone screw may also be formed using any other resorbable or biocompatible material, such as allograft, ceramics, ceramic-polymer mixtures, or with non-resorbable materials such as titanium. It should also be appreciated that the staple may be formed of any suitable material that is capable of locking the bone screw and/or securing a bone graft.

[0033] With specific reference to Figures 1-3, an implant, or bone screw, 10 is illustrated generally to be a channeled screw including a top surface 12, a bottom portion 14, a contoured portion 16 and screw channels 18 that define anchor locking surfaces 20. Top surface 12 includes a graft holding face

26 with spikes 28 extending therefrom. Graft holding face 26 and spikes 28 bindingly engages a material such as a soft tissue graft and will be discussed later in more detail. Contoured portion 16 is illustrated to define a threaded surface intersecting channels 18 to define threaded end surfaces 30. Channels 18 are formed within bone screw 10 to provide a torque surface 32 for implantation of bone screw 10, as discussed hereinafter. Anchor locking surfaces 20 include a series of resilient, downwardly facing surfaces 34.

[0034] Referring now briefly to Figure 4, a tap or driver 40 is illustrated to include a shaft 42, driving portions 44 defining linearly spaced cutting, or thread forming, portions 46 and alignment ends 48. Driving portions 44 are bifurcated with respect to shaft 42. Tap 40 is formed of titanium or of any suitable material for forming threads in a working surface, such as a bone, as described below. Thread forming portions 46 are illustrated to include a plurality of linearly spaced extensions configured to cut a predetermined surface within a work material, as detailed herein.

[0035] Figures 5-7 illustrate a screw implantation system 60 comprising the bone screw 10 and the tap or driver 40. Driving portions 44 of tap 40 are interposed within screw channels 18 of bone screw 10 such that thread forming portions 46 and threaded end surfaces 30 are generally aligned.

[0036] With specific reference to Figure 7, screw implantation system 60 is illustrated with a work material such as a bone 70 to provide an environmental reference. Bone 70 includes a pre-drilled aperture 72 having a generally cylindrical interior surface 74.

[0037] With continued reference to Figure 7, the implantation of bone screw 10 will be described. When a self tapping fastening system is desired, a surgeon prepares a bone 70 by drilling or otherwise forming an aperture 72 therein. Tap 40 with bone screw 10 engaged therein is inserted into aperture 72 until alignment ends 48 are in contact with bone 70. Rotation of shaft 42 of tap 40 causes thread forming portions 46 to engage interior surface 74 of bone 70 thereby forming an implant engaging surface 76 within bone 70. As implant engaging surface 76 is formed by tap 40, contoured portion 16 of bone screw 10 engages implant engaging surface 76. Further rotation of tap 40 causes bone screw 10 to fully engage within implant engaging surface 76 such that bone screw 10 is further threaded into aperture 72. Thus provided, tap 40 drives bone screw 10 into aperture 72 while simultaneously forming implant engaging surface 76. Contoured portion 16 mates with implant engaging surface 76 to retain implant 10 in bone 70. It would be appreciated that, while contoured portion 16 is illustrated as having a threaded surface, contoured portion 16 can be provided with any surface that engages with an implant engaging surface formed within bone 70. When bone screw 10 has been inserted into aperture 72 to a desired engagement or depth, tap 40 is pulled out of aperture 72 in a direction that is parallel to the axis of bone screw 10. As tap 40 is pulled, a slot 80 (as best seen in Figure 13) is formed by each driving portion 44.

[0038] Referring now to Figures 8-9, a staple 90 is illustrated to include a top portion 92 defining a contoured, or graft holding surface, 94, legs 96 defining upward locking surfaces 98 and a bottom portion 100. Graft holding

surface 94 is illustrated to include spikes 102 that are configured to bindingly engage a graft as described herein. Staple 90 may be constructed of titanium or stainless steel, or other biocompatible material.

[0039] With reference now to Figures 11-13, additional features of bone screw 10 will now be described in detail. As best seen in Figures 12 and 13, bone screw 10 is implanted, or driven, into aperture 72 of bone 70. Slots 80 are formed within bone 70 as discussed above, and provide a pair of rectangular channels 110 that align with screw channels 18 of bone screw 10. Staple 90 is inserted into screw channels 18 and rectangular channels 110 until downwardly facing surfaces 34 engage with upward locking surfaces 98. Thus provided, staple 90 is locked within screw channels 18 and rectangular channels 110 such that bone screw 10 is inhibited from rotation relative to bone 70. Staple 90 can be further inserted into screw channels 18 and rectangular channels 110 to provide greater engagement depth and/or clearance.

[0040] An additional feature of bone screw 10 is illustrated in Figure 11 wherein a soft tissue graft 120 is interposed between staple 90 and bone screw 10. In the embodiment shown, bottom portions 100 of staple 90 are inserted into screw channels 18 and rectangular channels 110 until upward locking surfaces 98 engage downwardly facing surfaces 34 and graft holding surface 94 bindingly secures graft 120 to graft holding face 26.

[0041] Figure 10 illustrates an alternate embodiment of staple 90 in accordance with the teachings of the present invention as a staple 90'. Staple 90' includes a top portion 92' defining a surface 94', legs 96' defining upward

locking surfaces 98' and a bottom portion 100. In the embodiment shown, staple 90' does not include spikes, and is intended for use as a screw locking member that couples to a bone screw 10 that does not include spikes 28. In this manner, staple 90' provides a low profile locking feature for bone screw 10.

[0042] Figures 14 – 17 illustrate an alternate embodiment of the implant of the present invention wherein the implant is intended to be axially, or linerally, driven into a bone. Figures 14 and 15 illustrate an implant 210 having a top surface 212, a bottom portion 214, a contoured portion 216 and screw channels 218. The top surface 212 is illustrated to include a torque surface 220. While contoured portion 216 is illustrated in Figure 15 as a series of annular protrusions 222, contoured portion 216 may also comprise a helical screw surface. Figures 16 and 17 illustrate an implant 310 having a top surface 312, a bottom portion 314, a contoured portion 316 and screw channels 318. The top surface 312 is illustrated to include a torque surface 320. While contoured portion 316 is illustrated in Figure 17 as a series of annular protrusions 322, contoured portion 316 may also comprise a helical screw surface.

[0043] During implantation, the implant 210, 310 is attached to an impact driver. Implant 210, 310 is then driven or impacted into a bone, thereby forming a pair of slots within the bone as contoured surface 216 displaces a portion of the bone. The bone may be prepared with an aperture that is about of equivalent diameter to the bottom portion 214, 314 of implant 210, 310. As presently preferred, the implants 210 and 310 are constructed of a material that is capable of being driven into a bone without damage to the implant 210, 310.

Implant 210, 310 is then rotated about 90 degrees to lock implant 210, 310 into the bone as contoured portion 216, 316 forms an implant engaging surface within the bone. Implant 210, 310 may be rotated by a tool attached to torque surface 220, 320. In a manner similar to implant 10, a staple may be inserted into the pair of slots formed into the bone to prevent rotation of implants 210, 310 to thereby lock the implant 210, 310 in place.

[0044] Figures 18 – 20 illustrate an alternate embodiment of the implant 10 and staple 90 of Figure 13. As best seen in Figures 18 and 19, staple 590 includes graft apertures 604. Figure 20 illustrates implant 510 to include graft pins 528. Graft pins 528 are configured to secure a graft between implant 510 and staple 590. Graft pins 528 are further configured to interpose within graft apertures 604 as staple 590 is attached to staple 510, thereby preventing the graft from detaching from graft pins 528.

[0045] Figures 21 – 22 illustrate a further alternate embodiment of the implant 10 and staple 90 of Figure 13. As best seen in Figure 21, staple 690 includes graft pins 702. Figure 22 illustrates implant 610 to include graft apertures 704. Graft pins 702 are configured to secure a graft between implant 610 and staple 590. Graft pins 702 are further configured to interpose within graft apertures 704 as staple 690 is attached to staple 610, thereby preventing the graft from detaching from graft pins 702.

[0046] Figures 23 and 24 illustrate a further alternate embodiment of the staple of Figure 8 wherein suture apertures are included to provide a suture attachment location for attachment of grafts to bone. Figure 23 illustrates a

staple 790 to include a suture aperture 799. Figure 24 illustrates a staple 890 to include an alignment aperture 897 and a suture aperture 899. Alignment aperture 897 may be used with a guide wire to ensure proper alignment of staple 890 during installation onto an implant 10. Alignment aperture 897 may also be used as a suture aperture 899.

[0047] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.